

Analysis of the Properties of Guiding Catheters Used in Endovascular Neurointervention

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Summary

The backup force is one of the most important properties of the guiding catheter in modern endovascular neurointervention employing rigid or bulky devices. Several guiding catheters were examined with regard to their backup force. Each guiding catheter had unique characteristics and neither an increase in its diameter nor increase in the backup force was directly proportional. The combined use of guiding catheters (coaxial guiding catheter) led to some improvement of the backup force, and the combination of the 6Fr Envoy and 8Fr Guider Softip exhibited the best performance. This article provides some scientific background as a means to select the appropriate catheter for beginners as well as accomplished operators.

Introduction

This decade promises many exciting and innovative endovascular treatment strategies and devices. With rapidly advancing technology, stent-assisted intracranial procedures are also becoming routine clinical practice^{1,2}. The guiding catheter is, of course, one of the indispensable instruments in all endovascular neurointerventions. Even with the stable behavior of the guiding catheter throughout the procedure, which is a fundamental key to treatment success, selection of an appropriate guiding catheter varies

and depends on the judgment of the treating physician or the opinions of experienced individuals. The backup force of guiding catheters, which is a unique property of critical importance, has never been defined and described exactly in the literature. In this study, we quantitatively measured the backup force of guiding catheters and provide a source of information for operators' selection of guiding catheters.

Materials and Methods

Guiding catheters

All guiding catheters used in this study are commercially available and commonly used, namely the Guider Softip (Boston Scientific, Natick, MA), with sizes ranging from 5-9 French (Fr), ENVOY/Vista Brite Tip (Cordis/Johnson and Johnson, Miami, FL) at 5-9 Fr, and Shuttle-SL Flexor (COOK, Bloomington, IN) at 5-8 Fr, respectively. These catheters were evaluated via single use or combination use (coaxial guiding catheter). In all examinations, a new catheter was used for each measurement.

Measurement of backup force

The backup force of guiding catheters is equivalent to the normal stress in the axial direction of the catheter. In this study, we used a specially manufactured instrument to measure the backup force of guiding catheters in conditions similar to actual treatment (figure 1). The

instrument consisted of a precision platform scale, a cylinder to hold the catheter in the axial direction, and a push-pull gauge. The guiding catheter was cut and adjusted to examine the part 15 to 50 cm from the catheter tip, which is positioned from the aortic arch to the proximal side of the carotid artery or the vertebral artery in actual treatment. The catheter was firmly clamped to the push-pull gauge at one end and was held at the other end in the cylinder to contact the platform scale axially. Then, both ends were brought together to within 1 cm manually with the gauge to bend the catheter. The weight measured on the platform scale was considered as the backup force of the guiding catheter in the bending state.

Results

Product properties

In the Guider Softip, the backup force of 6 Fr was smaller than that of 5 Fr. In addition, the backup force of 9 Fr (the maximum diameter) was remarkably lower than that of 8 Fr, and was attenuated rapidly by the bending of the catheter. The backup force of all sizes of the Guider Softip except 5 Fr was attenuated rapidly as the bend increased, and when 7-11 cm bends became almost 0, though those were large enough in the first stage of the bend (figure 3A). All Guider Softip catheters tended to bend greatly at a point about 1/3 from the tip (figure 2A), and the backup force of the catheter was attenuated rapidly when this part began to bend.

The Envoy/Vista Brite Tip showed the gradual attenuation to the bend; consequently, the backup force became 0 when the bend increased to 13-18 cm, although the backup force in the first stage of the bend was a smaller than that of the Guider Softip (figure 3B). In addition, the bent shape of the catheter, a smooth circular arc, was contrasted with the case of the Guider Softip (figure 2B). The backup force of 8 Fr (the maximum diameter) was attenuated rapidly due to the bending of the catheter, resulting in the same level as that of 7 Fr with a 7 cm bend. The Shuttle-SL Flexor bent in a smooth circular arc as well as the Envoy/Vista Brite Tip (figure 2C), and the backup force was attenuated gradually with bending (figure 3C). Interestingly, neither the diameter increase nor the backup force of the catheter was directly proportional in all products.

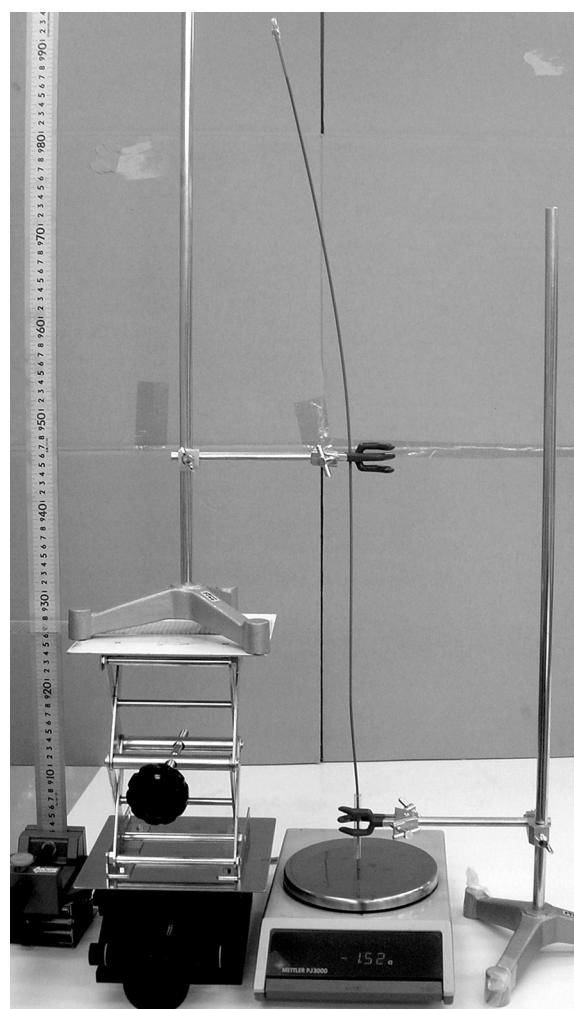


Figure 1 A specially manufactured instrument to measure the backup force of guiding catheters, consisted of a precision platform scale, a cylinder to hold the catheter in the axial direction, and a push-pull gauge.

Comparison with the same size

Each product was compared with others of identical sizes. At 5 Fr, the backup force of the Guider Softip was excellent, and attenuation by bending was also small (figure 4A). The backup force of the Shuttle-SL Flexor was greater than that of other 6 Fr-sized products. As for the Guider Softip, rapid attenuation by bending was marked, though the backup force was larger than Envoy in the first stage of the bend (figure 4B). There was no obvious difference in performance between each product at 7 Fr (figure 4C).

The backup force of each product was considerably larger in the first stage of the bend with 50-60 grams at 8 Fr. Especially, the Shut-

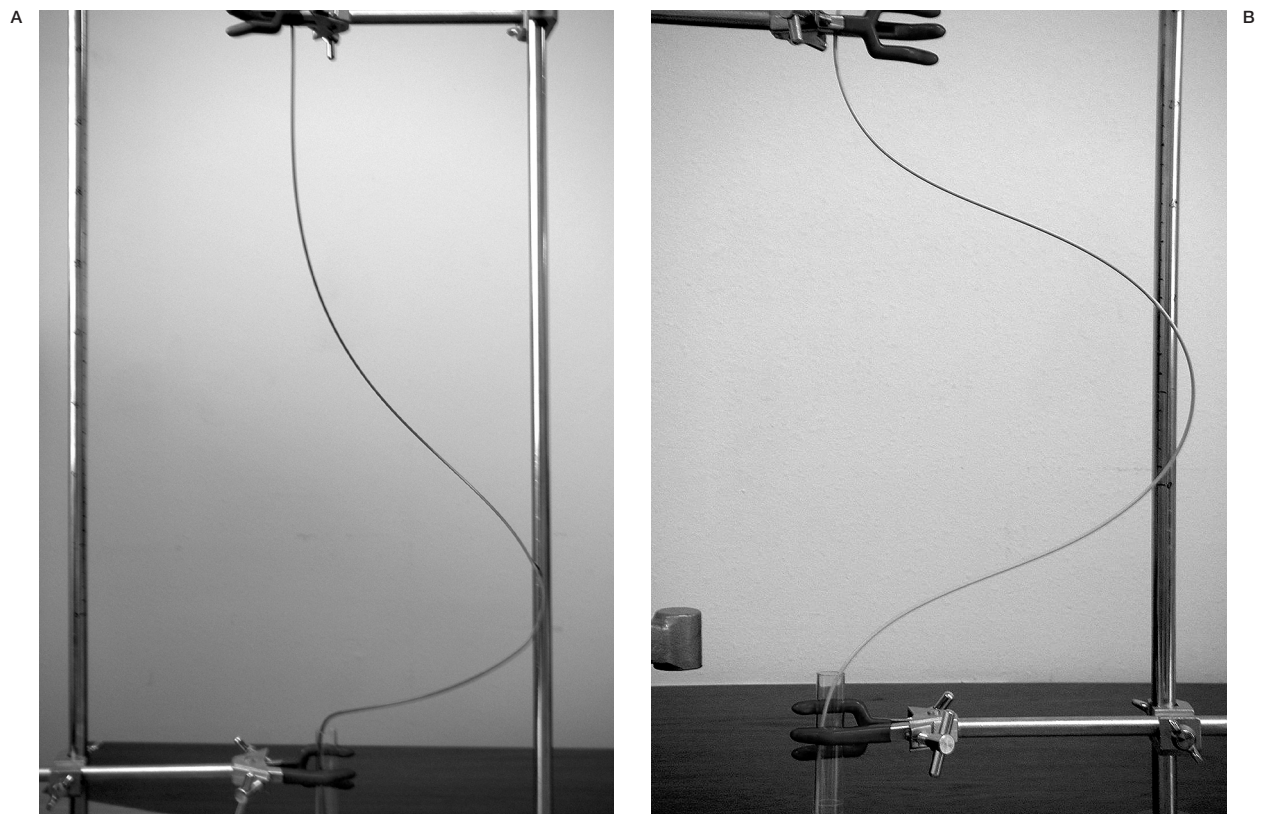
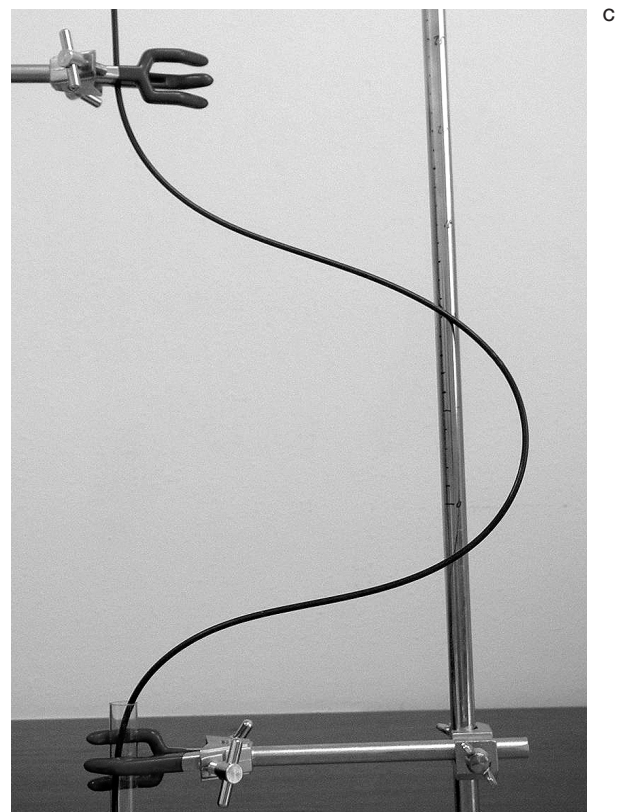


Figure 2 The bent shape of the catheters. All Guider Softip catheters (A) tended to bend greatly at a point about 1/3 from the tip. On the other hand, the bent shape of the Envoy/Vista Brite Tip (B) and the Shuttle-SL Flexor (C) was a smooth circular arc.

tle-SL Flexor showed an excellent performance with slight attenuation by bending (figure 4D).

Combination use (coaxial guiding catheter)

The combined use of guiding catheters is a technique often used to obtain a greater backup force. In this study, representative combinations were evaluated via multiple combinations. The combination of the 6 Fr Envoy and 6 Fr Shuttle-SL Flexor showed that the backup force increased on not only initial bending but also over the entire area of the bend. Furthermore, in the combination of the 6 Fr Envoy and 8 Fr Guider, the backup force of initial bending was large, about 70 grams, and attenuation was maintained quite gradually at a high level of 30 grams or more at the measurement limit of the instrument. The backup force of this combination corresponded from 1.5 to twice or more that of the combination of the 6 Fr Envoy and



6 Fr Shuttle-SL Flexor over the entire area of the bend. On the other hand, the combination of the 6 Fr Guider and 8 Fr Guider showed that the backup force became considerably large in the first stage of the bend, but was attenuated very rapidly as the bend grew, resulting in 0 grams at a bend of 12 cm (figure 5).

Discussion

Though a number of factors influence the choice of a guiding catheter, the backup force is one of the most important properties of the guiding catheter and is often the crucial determinant of treatment success or failure. A better backup force is necessary in order to improve the primary success rate, especially when balloon catheters or stents are used¹⁻³.

In some patients with stenosis of an intracranial artery, the guiding catheter buckles into the aorta and is often pushed back from its position during an attempt to place the balloon or stent, because these devices are bulky and rigid. Additionally, we often encounter tortuous anatomy of the aortic arch, carotid arteries, or vertebral arteries, in which the guiding catheter bends greatly. Therefore, we need to compare and understand various guiding catheters objectively with regard to their backup force on bending, in the context of both single use and combination use.

The data presented in this study showed that each guiding catheter has different characteristics regarding the backup force. The Guider Softip is a guiding catheter developed specially for endovascular neurointervention owing to the original shaft construction and braid design. From the manufacturer information, this catheter is made of a structure of varying stiffness, consequently providing a stiffer hand shaft and a more flexible tip. On the other hand, our data revealed its peculiar characteristic of a large backup force at the early stage of bending and rapid attenuation when the bend grows. This feature showed that all catheters using this product tended to buckle greatly at the same point and that the backup force of the catheter was attenuated rapidly when the part began to bend. This peculiar characteristic of the Guider Softip might reveal that the transition between the parts might be too abrupt at the point.

In contrast, the backup force of the Envoy/Vista Brite Tip was inferior to that of the

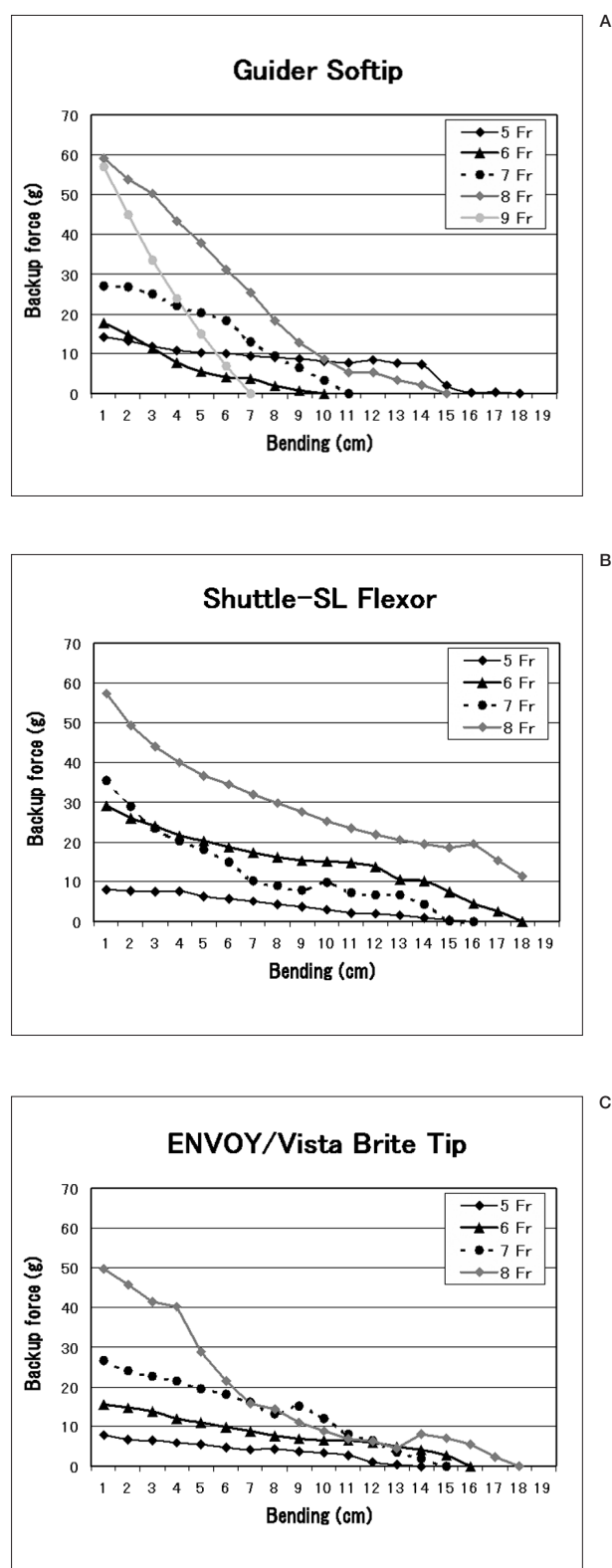


Figure 3 The backup force in the bending state of the Guider Softip (A), the Envoy/Vista Brite Tip (B), and the Shuttle-SL Flexor (C).

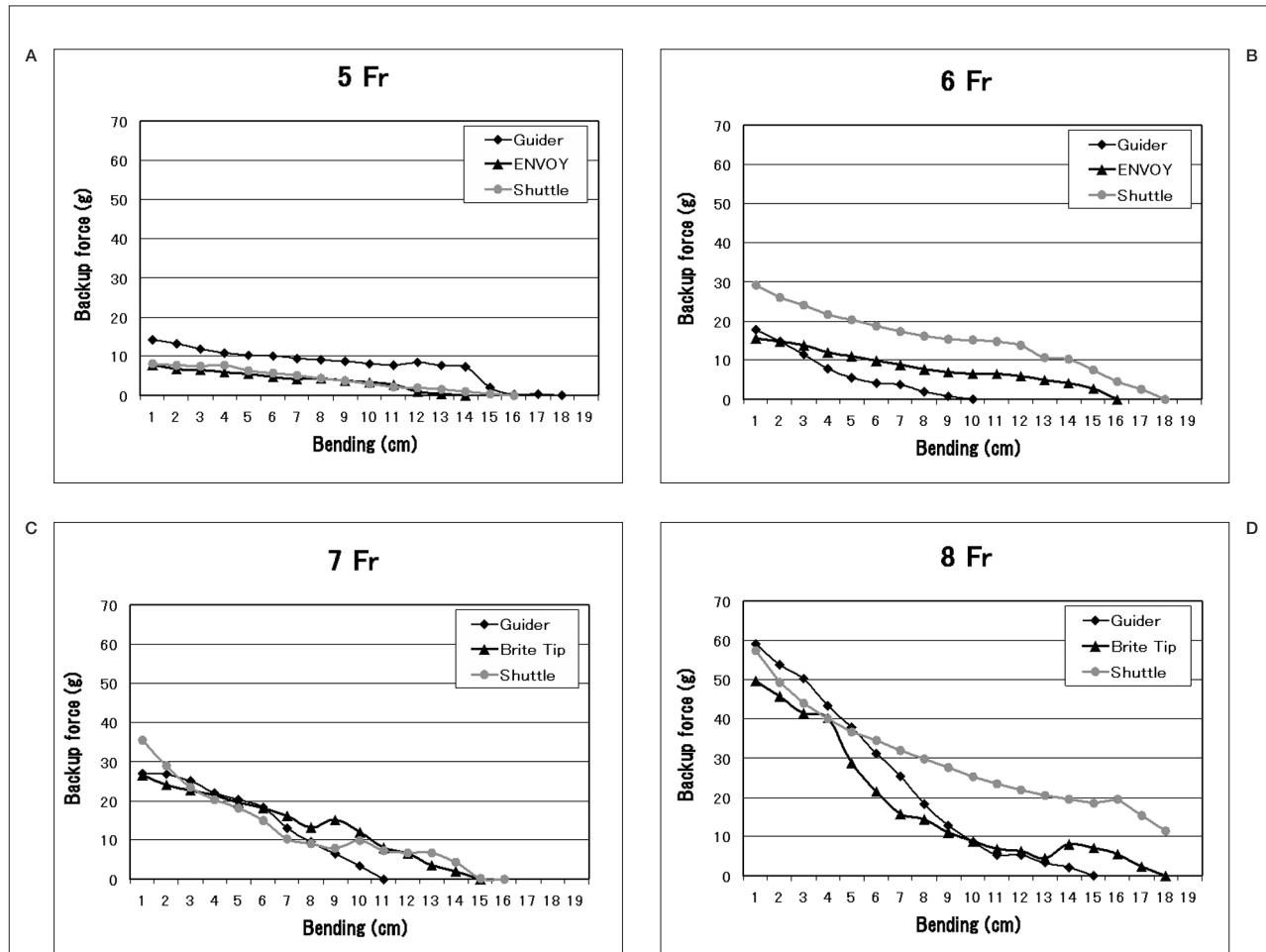


Figure 4 The backup force of the guiding catheters in the bending state was compared with the same size of 5Fr (A), 6Fr (B), 7Fr (C), and 8Fr (D) respectively.

Guider Softip in the first stage of bending; however, it was prolonged with bending. The difference in the backup force on bending could be explained by the gradual transition between the shaft parts in four or five stages. Likewise, the Shuttle-SL Flexor bent in a smooth circular arc and had a prolonged backup force on bending.

In all these products, neither an increase in the diameter nor increase in the backup force was directly proportional. In a certain product or French size, the balance of materials and wall thickness might not be matched with the diameter of catheters.

The combination use of guiding catheters (coaxial guiding catheter) may be useful in some patients referred for stent placement of distal intracranial stenotic lesions or stent graft placement of complicated aneurysms^{1,3}. In such

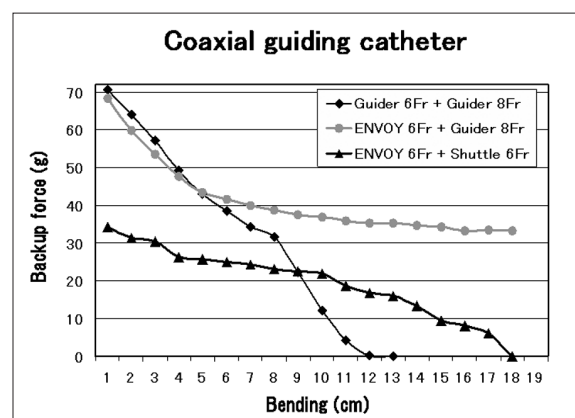


Figure 5 The backup force of the guiding catheters in the bending state at combination use (coaxial guiding catheter). Any combination showed some improvement of the backup force. The combination of the 6Fr Envoy and 8Fr Guider Softip showed the best performance among the various combinations.

cases, buckling of the introducer sheath or the guiding catheter back into the aorta frequently occurs. Our results concerning this technique were interesting. Any combination showed some improvement of the backup force, with guiding catheters acting compensatorily, i.e., both merits and the demerits were emphasized in the same products used in combination, and the faults of one product were compensated for by the advantages of the other. For instance, combination of the 6 Fr Envoy and 8 Fr Guider Softip showed that the backup force on initial bending was markedly elevated because of the characteristic of the Guider Softip with about 70 grams, and the attenuation became gradual due to the characteristic of the Envoy. On the other hand, the backup force in the combination of the 6 Fr and 8 Fr Guider Softip became maximal in the first stage of the bend and exhibited a more accelerated attenuation as the bend grew. As shown in the results, combination of the 6 Fr Envoy and 8 Fr Guider Softip showed the best performance among the various combinations. Combination of the 6 Fr Envoy and 6 Fr Shuttle-SL Flexor also led to a sufficiently large backup force over the whole area of the bend, with the advantage of avoiding major groin complications due to the larger size of the guiding catheters.

This article aims to provide some scientific background as a means to select the appropriate catheter for beginners as well as for accomplished operators and encourage manufacturers to develop the instrumentation. Of course, there is no intention of recommending a particular product to physicians.

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